PANAMA CANAL LIGHTING SYSTEM MINUTELY EXPLAINED

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The following facts, prepared by William M. Baxter, Jr., official guide and lecturer of the Isthmian Canal Commission, will be found a descriptive, instructive, and interesting story from an absolutely reliable and authoritative source.

The Canal Zone is a strip of land ten miles wide, five miles each side of the center line of the canal, extending from the Atlantic to the Pacific. All told, it contains 436 square miles, of which the United States now owns about 363 square miles. The remainder is privately owned and was not acquired by the government.

The two cities of Panama and Colon, although within the boundaries of the Canal Zone, are excluded from it and are under the government of Panama. They have no outlet, however, except through the zone. The United States reserves the right to enforce sanitary ordinances in those two cities, and also to maintain public order in the event that the Republic of Panama is unable to do so.

The canal traverses this zone from Colon to Panama in a general southeasterly direction, Panama being located 22 miles east of a line running due south from Colon.

In passing through the canal from the Atlantic vessels enter a sea-level channel extending from deep water in the Atlantic to the foot of the locks at Gatun. This channel is 7 miles in length, 500 feet wide, and 41 feet deep.

At Gatun, vessels are lifted from sea level to 85 feet above through a flight of three locks, passing directly into the waters of Gatun lake.

Gatun lake is an artificial body of water with an area of approximately 164 square miles. This lake is formed by impounding the waters of the River Chagres and its tributaries by means of a large dam at Gatun, where there is a break in the range of hills which surround the basin of the Chagres.

Vessels after entering the lake may go at practically full speed for a distance of 23 miles from Gatun to the mouth of the cut. The first 16 miles of the channel through the lake is to be 1000 feet wide, and is marked by buoys on the surface of the lake; then for 4 miles the channel is to be 800 feet wide, narrowing to 500 feet for 3 miles before entering the cut.

Passing through the Miraflores Lake, a distance of a mile and a half, through a channel 500 feet in width, the vessels arrive at the Miraflores Locks and pass down through two locks in flight from 55 feet above sea level to the sea-level channel on the Pacific side, steaming out through this channel from the foot of the locks at Miraflores to deep water in the Pacific, a distance of 8 miles.

The total length of the canal is 50½ miles and the time for passing through from one ocean to the other will be from 10 to 12 hours, according to the speed a vessel maintains in the lake area. Three hours of this time are taken up in passing through the six locks. Of the total length of the canal, 40 miles will be of sufficient width to allow vessels to go at practically full speed, there being 15 miles of sea-level channel, 7 on one side and 8 on the other, and 25 miles of open lake navigation in the two lakes, in all of which the minimum channel width is to be 500 feet, and the maximum 1,000 feet.

Everywhere except through the locks vessels will go under their own power.

The general conception seems to be that the Pacific ocean is higher than the Atlantic; this, however, is not the case. Mean sea level, the point midway between extreme high and low tide, is exactly the same in both the Atlantic and the Pacific. The difference is all in the tides. There is an average tide on the Pacific of 20 feet, while there are approximately but 20 inches of tide on the Atlantic side.

This excessively high tide on the Pacific side is apparently due to the shape of the Bay of Panama.

Breakwaters are being constructed on both the Pacific and the Atlantic sides. The one on the Pacific end is simply an extension of a large dump at East Balboa of material excavated from the Culebra Cut, connecting Naos Island with the mainland, and designed to cut off a cross current which comes in at right angles to the line of the canal.

Electric Locomotives.

The protective devices are one of the most interesting features of the lock construction, and of these the electric locomotives are the most important. About 90 per cent of all accidents to other locks have been due to misunderstanding in signals between the captain and engineer of the vessel, and all accidents of that kind will be eliminated by requiring vessels to go through the locks in tow or electric locomotives operating on the center and side walls of the locks. A vessel comes in and ties up to the center wall, which is extended beyond the side walls at both the upper and lower ends of the lock simply to act as a wharf or mooring wall. The vessel waits here until the locomotives come down and tow it up to a point where the locomotives on the side walls make fast their lines. The vessel then goes into the lock chamber with two locomotives in front towing, one on either side, and two others behind to retard when she gets into proper position.

These towing locomotives operate on tracks close to the edge of the wall and engage in a center cog rail. While running on this cog rail the maximum speed at which they can operate will be 2 miles per hour. When they have completed a tow, however, they switch over to a track farther back from the edge of the wall, and here the cog rail is omitted so that they can return at a greater speed.

Protective Chain.

Should a vessel not obey the order to stop out alongside the center wall, but come ahead, it first would encounter a chain stretched across the entrance to the lock chamber. This chain connects on either side with large hydraulic cylinders located in shafts in the lock walls. The pressure from these cylinders causes the chain as it plays out to offer more and more resistance to the motion of the vessel. The chain is capable of stopping in 70 feet a 10,000 ton vessel running 4 miles per hour. The stock from which it is to be forged is three inches in diameter.

When not in use the cylinders are forced up, and the weight of the chain carries it down into the groove in the bottom of the lock floor, and the vessel passes over it.

Guard Gates.

If a vessel should break through the fender chain, it would then ram the lock gate, but with this contingency in view, two gates instead of one have been provided at the upper and lower ends of the highest lock in each flight, the upper or guard gate of each pair serving to protect the lower gate from ramming. Both gates would have to be broken down to put the lock out of commission.

Lower Guard Gate.

At the lower end of all the sets of locks a small guard gate has been put in, mitering the other way from the main lock gates, which miter toward the high level, and it has been designed to serve two purposes: First, as a coffer gate or dam, if at any time it is necessary to pump the water from the lower lock chamber; second, as a guard gate to the lower lock gate, for, mitering as it does, it will stand a heavier blow from the lower side than the lock gate itself.

Emergency Dam.

If all of these devices should fail and there should be an accident which would establish free communication between the two levels above and below a lock, a most destructive accident would be the result, for the velocity of the water flowing through the lock chamber would be 24 feet per second, and the discharge would amount to 90,000 cubic feet per second. In order to shut off this water, and prevent it from tearing out the lock floor, it is necessary to employ a device known as an emergency dam, of which there are two installed at the upper end of each set of locks, one for either side. These resemble a swing bridge, and when put in use they are swung out across the lock, and from their lower side a set of open-work wickets are lowered, engaging in a grooved sill on the lock floor.

Lock Gates.

The construction of the lock gates is also interesting. They were built up of big horizontal girders weighing from 12 to 18 tons each, with vertical framework in between, and the sheathing plate both on the outside and inside of this frame. They are cellular in construction, and the lower half of the gate is an air chamber, which supports about three-quarters of the weight of the gate when submerged. The upper half of the gate is arranged with openings in the plates on the upstream side, so that water can flow in or out of the upper half of the gate at the same time that it flows in and out of the lock, increasing the weight of the gate as the height of the water on the outside increases, overcoming in that way the lifting effect of the air chamber in the bottom of the gate, as it is placed deeper and deeper under the water.

These gates vary in height from 47 to 82 feet, and in weight from 300 to 700 tons to each half gate. If each half gate were laid flat one on top of the other they would build up a tower containing 58,000 tons of steel, standing 32 feet higher than the Singer Building in New York. There are 92 half gates, and each is 7 feet in thickness.

Another interesting comparative figure is one pertaining to the excavated material. All of the excavated material which will have been taken out when the canal is completed, including the 30,000,000 cubic yards of useful French excavation, if loaded on one train of flat cars similar to the wooden cars one sees commonly on the work, would make a train over 110,000 miles long, reaching more than four times around the earth.

Sanitation.

Not one single factor has been more important in making the construction of this canal a possibility than that of sanitation. One of the worst snags that the French ran against was this very question of sanitation. Unfortunately there are no accurate figures obtainable on the lives lost during the French time; the only figure available is for the mortality in Ancon Hospital, which for the eight years between 1881 and 1888 amounted to 5,527. But the French were at this time doing their work by contract, and each contractor was charged a dollar per day for each man he had in hospital. It will readily be understood, therefore, that if the French contractor were anything like the ordinary contractor, not a very large proportion of the sick would go to this hospital. We hear of many individual instances of heavy loss. The first French director, Mr. Dingler, came to the Isthmus with his wife and three children. At the end of the first six months all had died of yellow fever except himself. One of the French engineers, who was still on the Isthmus when we first arrived, stated that he came over with a party of 17 young Frenchmen. In a month they had all died of yellow fever except himself. The superintendent of the railroad brought to the Isthmus his three sisters; within a month they had all died of yellow fever. The mother superior of the sisters nursing in Ancon Hospital told me that she had come out with 24 sisters. Within a few years 21 had died, the most of yellow fever. Many other instances of this kind could be cited. During the eight years that the Americans have been at work on the canal, the death roll has reached 5,141, of which 995 have been deaths from violence.

Active work was started by the French on their canal in 1881, and this first French company, which was organized by De Lesseps, failed during the latter part of 1888, after spending $200,000,000. For five years the company remained in the hands of a receiver, and in 1894 the new French company was organized and kept up the work on a very small scale until 1904, when the United States took over the construction.

The rights and property of this French company were purchased by the United States for $40,000,000, and up to date our country has realized on this purchase, on a very conservative estimate, over $42,000,000.

Out of the 80,000,000 cubic yards of excavation work which the French company had done only 30,000,000 yards were useful in the construction of the present type of canal, and in estimating the value of the French purchase an allowance of $25,389,240 was made for this excavation work. It had cost approximately $120,000,000.

The value of the Panama Railroad was estimated at $9,000,000. This railroad was acquired by the French at a cost of $18,000,000. In addition to these two main items, the purchase included a great deal of machinery, and the commission is today using 85 French locomotives and 7 ladder dredges included in the property purchased.

The Gatun Dam.

The Gatun Dam is a huge earth structure, and is, in fact, more of a mountain than a dam. It is so constructed as to complete the natural range of mountains which, excepting at this one point, entirely surround the low-lying basin of the Chagres. By completing this basin it is possible to retain the waters of the Chagres, and thereby form the Gatun Lake.

The dam is constructed of two outer walls of dry fill, a large part of which was excavated from the Culebra Cut. These two walls, or toes, as they are usually called, were constructed so as to be 1,200 feet apart (inside measurement) and this space in between the two walls was filled with a mixture of sand and clay which was sucked up from the river bed of the Chagres, both above and below the dam, by means of large suction dredges, and then pumped through long pipe lines into the space between the two walls of dry-earth fill. About 20 per cent of the material passing through these pipe lines was solid matter, the balance water. After the solid matter settled the surplus water was drained off, and in that way the inner portion of the dam was built up. This inner core is usually known as the hydraulic core, and forms the water-tight portion of the dam. After the hydraulic core had been carried a short way above the water level it was discontinued, and the outer walls were then carried higher and closer together until they entirely encased and capped over the inner core.

The Gatun Dam at the base is 2,100 feet, or about half a mile, thick—400 feet thick at the water surface and 100 feet wide across the crest. The crest of the dam stands 105 feet above sea level, and 20 feet above the surface of the water of the lake. The length of the dam measured along the crest is 7,500 feet, but of this length only 500 feet will be subject to the full pressure of 85 feet of water, due to the natural rise of the ground along the inner slopes of the dam.

In connection with this dam it is interesting to know that a Frenchman named Lepinay was the first to propose the plan of constructing a dam at Gatun. He proposed this plan in 1879 to the International Scientific Congress, which had been convened at Paris to determine upon the general route of the proposed canal, but De Lesseps, who was the leading spirit of this Congress, was so strong an advocate of the sea-level canal that Lepinay's plan was hardly discussed, and is simply a matter of record.

The spillway which is located about midway of the dam, is built right into a natural hill which stood at an elevation of 110 feet above sea level. This hill was practically solid rock, so it was only necessary to cut a channel 300 feet wide through this hill and line it with concrete, building a dam across the head of this channel to form the spillway or regulating works for Gatun Lake. This dam forms nearly a semi-circle across the head of the spillway channel, and will be constructed of solid concrete up to elevation 69. At this level piers rise 45 feet apart on the crest of the solid portion of the dam, and in between these piers come the steel gates 19 feet high, which control the level of the lake.

With these gates closed the crest of the dam would be 88 feet above sea level, so that it would be possible to store up water in the Gatun Lake up to about 87 feet above sea level. The normal level of the lake is to be 85 feet, and it will be maintained at that level during most of the year; just at the last of the rainy season, however, the lake level will be brought up to 87 in order to supply the water for lockages during the dry season.

Locks

There are six locks in the canal, three in flight at Gatun, one at Pedro Miguel, and two in flight at Miraflores. All locks are constructed in pairs, so that vessels can go in opposite directions at the same time. Each lock or flight of locks is in general to be reserved for ships going in one direction, the twin lock or flight being used for vessels going in the opposite direction.

The length of the lock chamber is 1,000 feet, the width 110 feet, and the depth of water over the sills 41 2-3 feet in fresh water and 40 feet in salt water.

The Pedro Miguel lock is the same in all the essential features as the other locks, and as there is only one lift at this point it is the best one to describe.

A simple definition of a lock is a walled chamber between two bodies of water of different levels have gates at either end, in which it is possible to confine vessels while they are being raised or lowered from one level to another by allowing water to flow in or out of the lock chamber.

The method of raising or lowering the level of the water in the lock chamber varies on different lock canals. The lock chambers on most of the old canals are emptied or filled through sluice gates that slide up and down in the lock gates themselves. This system, however, caused a great deal of surging of the water at that end of the lock at which it was flowing in or out, and the system that has been adopted on the Panama Canal was designed with the idea of avoiding this disturbance of the water in the lock.

All the locks on the Panama Canal have two parallel lock chambers, separated by a center wall. The water is brought in or out of these chambers through huge tunnels 18 feet in diameter passing lengthwise of the lock through the center and side walls. Branching out from these tunnels at right angles and running out under the lock floor are laterals, and these laterals communicate with the lock chamber through openings in the lock floor. The flow of water in or out of the lock is controlled by the gate valves located at both the upper and lower ends of the feed tunnels. In order to raise the water in the lock chamber the valves at the lower end are closed and the ones at the upper end opened. The water then flows from the upper level into the lock, passing down the tunnel in the side wall, and out through the laterals under the floor, coming up through the openings in the floor. It continues to flow in this way until the elevation of the water in the lock chamber is the same as that of the water above. To lower the water in the lock the process is simply reversed. The upper valves are closed and the lower ones opened. The water then flows out from the lock chamber and, passing back through the same tunnels that brought it in, seeks the level of the water below. So that in order to raise a vessel from one level to another the level of the water in the lock chamber is brought to the same level as that at which the vessel stands.

The lock gates are then opened, the vessel passes into the chamber, and the gates are closed. Water is then allowed to flow into the lock until the vessel is raised to the level of the upper body of water, and with the same level on both sides of the upper gates those gates are thrown open, the vessel passing out at a greater elevation than that at which it entered the lock.

The big tunnels passing through the side walls are the main operating tunnels, the one through the center wall being an auxiliary used to assist in filling the lock during the latter part of the operation, thereby increasing the volume of the inflow at the time when the velocity of the water entering the lock from the side wall tunnels is decreasing, keeping up in that way an average rate of filling which would amount to about two feet per minute. So that at Pedro Miguel, where the lift is 30 feet, a vessel would be raised from one level to the other in 15 minutes. The desired rate of filling can be kept up for the 600-foot and 400-foot locks by the side culvert only. It is probable that the center wall tunnel will be used only in case of the 1,000-foot lockages.

Interesting Facts and Figures

Length of canal from deep water to deep water, miles	50½
Length from shore line to shore line, miles	40
Time of transit through completed canal, hours	10 to 12
Time of passage through locks, hours	3
Bottom width of channel, maximum, feet	1000
Bottom width of channel, minimum, 9 miles, Culebra Cut, feet	300
Locks, in pairs	12
Locks, usable length, feet	1000
Locks, usable width, feet	110
Gatun Lake, area, sq. miles	164
Gatun Lake, channel depth, feet	85 to 45
Culebra Cut, channel depth, feet	45
Excavation, estimated total, cubic yards	212,504,138
Excavation, amount accomplished to Jan. 1, 1913, cubic yards	188,280,312
Excavation by the French, cubic yards	78,146,960
Excavation by French, useful to present canal, cubic yards	29,908,000
Excavation by French, estimated value to canal	$25,389,240
Value of all French property	$42,799,826
Concrete, total esitmated for canal, cubic yards	5,000,000
Weight of 1 cubic yard of concrete or earth, pounds	3000
Relocated Panama railroad, estimated cost	$9,000,000
Relocated Panama railroad, length miles	47.1
Maximum grade on Panama railroad, per cent	1.25
Maximum curve on Panama railroad, degrees	7
Gauge of Panama railroad, feet	5
Canal Zone, area, sq. miles	448
Canal and Panama railroad force actually at work (about)	35,000
Canal and Panama railroad force, Americans (about)	5000
Cost of canal, estimated total	$375,000,000
Amount spent by French	$260,000,000
Work begun by Americans	May 4, '04
Date of official opening	Jan. 1, '15
Population of Colon	17,740
Population of Panama City	37,505
Tide on Pacific side, feet	20
Tide on Atlantic side, inches	26
Area drained by the Chagres river square miles	1320
Average rainfall at Colon, inches	130
Average rainfall at Panama, inches	70
Average rainfall at Porto Bello, inches	173
Maximum rainfall of record for 3 minutes, inches	2.46
Maximum rainfall of record for 1 hour, inches	5.86
Maximum rainfall of record for 24 hours, inches	10.86
Maximum temperature of record, degrees Fahrenheit	96.6
Minimum temperature of record, degrees Fahrenheit	59
Average mean temperature	79
Mean relative humidity, per cent	89
Evaporation per annum, inches	52
Maximum momentary discharge of Chagres at Gamboa, cubic feet per second	170,000
Volume of water passing over the Horseshoe Falls at Niagara, cubic feet per second	250,000
Average amount excavated in 8 hours by each steam shovel in cut, cubic yards	1500
Record for 8 hours for steam shovels of any class, cubic yds.	5554

Jewelry amounting to $1000 in value has been stolen from the home of Theodore Roosevelt at Oyster Bay. A colored employe is suspected of the theft.